SPECIFICATION

HIGH DENSITY FABRIC FOR AIR BAG AND METHOD FOR MANUFACTURING HIGH DENSITY FABRIC

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a high density fabric for air bag and method for manufacturing high density fabric which is suitable for a fabric of air bag, one of safety apparatuses of automobile, and more specifically to a high density fabric for air bag having low air permeability, as well as excellent air permeability characteristics under high pressures while maintaining necessary mechanical properties.

Description of the Related Art

In recent years, the number of automobiles equipped with an air bag as a car safety component has rapidly increased in association with rising awareness of safety of passengers. An air bag is useful for protecting a passenger at the time of collision accident of automobile by sensing the collision with a sensor and causing an inflator to generate gas of high temperature and pressure to allow the air bag to rapidly expand.

Conventionally, base fabrics on which synthetic rubber such as chloroprene, chlorosulfonated olefin, silicone have been used for the purpose of achieving heat resistance, air insulation (permeability) and flame resistance.

However, such coated base fabrics had many drawbacks when used as a base fabric for air bag. That is, the weight of base fabric increases, the softness is deteriorated, the production cost increases and recycling is difficult. Though some of silicone-coated base fabrics currently used have considerably improved the above-mentioned drawbacks, they are not still satisfactory.

For this reason, non-coated base fabrics for air bag on which coating is not made are latest mainstream, and various proposals have been made for achieving reduced weight, desirable storability and lower air permeability. Under such current circumstances, base fabrics of further reduced weight and lower air permeability are requested as non-coated air bag base fabric.

Furthermore, in case of weaving high density fabric, when the weaving speed is increased in an attempt to increase productivity, yarn damages are increased due to frictions between the fibers and with reed, with the result that problems occur such as to give undesirable effects to the physical properties of the foundation. There is strong desire to obtain measures for settling these points.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a high density fabric suitable for air bag and method for manufacturing high density fabric, by obtaining a fabric of low air permeability and reduced weight having a stable fabric strength mechanical

property and excellent air permeability characteristics under high pressures that has not been solved by the above-mentioned conventional methods.

Means for solving the above object, that is, the first aspect of the present invention is a high density fabric for air bag wherein air permeability under a differential pressure of 50 kPa is 2.5 L/cm^2/min. or less, and air permeability index (50 kPa) calculated by the formula (1) is 1.2 or more.

Air permeability index (50 kPa)

=(Log (Q(55 kPa))-Log(Q(45 kPa)))/(Log55-Log45) (1)

Q(55 kPa): air permeability under 55 kPa differential pressure (1 /cm^2/min.)

Q(45 kPa):air permeability under 45 kPa differential pressure (1 /cm^2/min.)

The second aspect of the invention is the high density fabric for air bag according to the first aspect, wherein the air permeability (50 kPa) is 1.3 or more, the third aspect of the invention is the high density fabric for air bag according to the first aspect, wherein the difference in crimp percentage between warp and weft is 4 % or more, the fourth aspect of the invention is the high density fabric for air bag according to the first aspect, wherein the degree of intermingle of raw yarn before weaving is 10 to 30 times/m, and the fifth aspect of the invention is the high density fabric for air bag according to the first aspect, wherein a cover factor calculated by the formula

(2) in the high density fabric is in the range of 1800 to 2400.

Cover factor = $A^{0.5} \times (W1) + B^{0.5} \times (W2)$ .... (Formula 2)

A: Coarseness of warp (dtex)

B: Coarseness of weft (dtex)

W1: Density of warp (stripes/in.)

W2: Density of weft (stripes/in.)

The sixth aspect of the invention is the high density fabric for air bag according to the first aspect, wherein the degree of intermingle of warp or weft of the high density fabric is 8 times/m or less.

Now, characterizations of the high density fabric suitable for air bag according to the present invention will be explained in detail. The difference in crimp percentage between warp and weft constituting the fabric is preferably 4 % or more, more preferably 5 % or more, and most preferably 6 % or more. The difference in crimp percentage of less than 4 % is not desirable because the air permeability under high pressures cannot be made large. The degree of intermingle of unwoven yarn (yarn taken out from woven fabric) in warp and/or weft is preferably 8 times/m or less, and more preferably 6 times/m or less. The degree of intermingles of unwoven yarn higher than 8 times/m is not desirable because the air permeability is high.

The air permeability under 50 kPa differential pressure in the present invention is 2.5 L/cm^2/min. or less, preferably 2 L/cm^2/min. or less, and most preferably 1.5 L/cm^2/min. or less.

If the air permeability under 50 kPa differential pressure exceeds 2.5 L/cm^2/min., the mechanical property in the expanded state is not satisfactory.

The air permeability index under 50 kPa differential pressure in the present invention is preferably 1.2 or more, more preferably 1. 3 or more, and most preferably 1.5 or more, with 1.8 or more being particularly preferred. The air permeability index of less than 1.2 is not desirable because collision to the passenger under high pressures at the time of expansion of the air bag is not sufficiently reduced.

The degree of intermingle of raw yarn is preferably 10 to 30 times/m, and more preferably 15 to 25 times/m. The degree of intermingle of less than 10 times/m is not desirable because fluff will generate to deteriorate the weaving efficiency and drawbacks due to the fluff increase to deteriorate the quality. On the other hand, the degree of intermingle of more than 30 times/m is not desirable because the remaining degree of intermingle of yarns constituting the fabric after weaving is large, so that low air permeability cannot be obtained, causing decrease of the strength.

The cover factor in the present invention is preferably 1800 to 2400, and more preferably 1900 to 2300. The cover factor of less than 1800 is not desirable because low air permeability cannot be obtained. The cover factor of more than 2400 is not desirable because troubles at the time of weaving increase to

deteriorate the productivity.

It is necessary that the shrinkage percentage by boiling water of the thermoplastic fiber used in the present invention is 5 to 15 %. If the shrinkage percentage by boiling water is less than 5 %, low air permeability cannot be obtained, while on the other hand, if the shrinkage percentage by boiling water is more than 15 %, the thickness of fabric after shrinkage is large, so that the compactness will be lost.

While the value of the shrinkage percentage by boiling water is preferably 5 to 15 %, 8 to 12 % is more preferred. While the temperature of heat treatment in the present invention is not particularly specified, heat treatment is usually performed at 100 to 200°C. It is preferred that heat treatment is performed at 160°C or less from the viewpoint of achieving low air permeability. While the treatment is performed by heat setter, boiling water bath and the like not specified means, it is possible to use a processing machine enabling about 0 to 15 % of over feed in the vertical and horizontal directions. The over feed at the time of boiling water treatment is more than 3 times, more preferably 5 times, and most preferably 10 times the over feed at the time of dry setting. In the boiling water treatment, it is not necessarily to use boiling water, hot water of 70 to 100°C can also be used. Incidentally, the over feed percentage at the time of boiling water treatment is 3 to 8 %, and preferably 4 to 6 %. The over feed percentage of less than 3 % is not desirable

because it is difficult to obtain a fabric of low air permeability. On the other hand, the over feed percentage of more than 8 % is not desirable, because the base fabric cannot fully shrink and cause troubles in treatment process.

While the way of weaving is not particularly limited, plain weave is preferred in consideration of the uniformity of the mechanical property of the base fabric, and various weaving machines such as air jet loom, rapier loom, water jet loom and the like can be used without any limitation.

As for the thermoplastic fiber constituting the air bag in the present invention, while the material is not particularly limited, aliphatic polyamide fiber such as nylon 6, nylon 66, nylon 46 and nylon 12, or homopolyester such as polyethylene terephthalate and polybutylene terephthalate is used without being particularly limited. However, in consideration of the economics and collision resistance, nylon 66, nylon 46, nylon 6 are particularly preferred. Furthermore, various additives may be contained or added in these synthetic fibers without causing any problems for the purpose of improving the process passing ability of the process of producing raw yarns and the post-treatment process. Such additives include, for example, antioxidant, thermo-stabilizer, smoothing agent, antistatic agent, flame retardant and the like.

Furthermore, general fineness and single yarn fineness of raw yarn to be used are preferably in the range of 100 to

550 dtex and 6 dtex or less, respectively. Preferably, the general fineness is in the range of 150 dtex to 470 dtex, and the single yarn fineness is 4.4 dtex or less. More preferably, the general fineness is in the range of 200 dtex to 400 dtex, and the single yarn fineness is 3.3 dtex or less. That is, if the general fineness is less than 100 dtex, the tensile strength and the tearing strength are not satisfactory in that part, while if the general fineness is more than 550 dtex, the softness of the fabric is deteriorated and storability is poor. If the single yarn fineness is more than 6 dtex, the softness of the fabric is deteriorated and storability is poor.

The characteristic constitution of the high density fabric manufacturing method according to the present invention is to carry out weaving fabric with the fiber filling percentage in the reed at the time of the weaving defined by the following formula to be 110 or less.

$$\text{Fiber filling percentage (\%)} = 11.3 \times N \times (D/\rho)^{0.5}/(\alpha/L)$$

N: Coarseness of yarn to be inserted in a reed wire (dtex)

D: Coarseness of warp (dtex)

ρ : Density of fiber (g/cm^2)

α : Reed space percentage (%)

L: Number of reed wires (string/cm)

According to this constitution, it has been possible to provide a method for manufacturing high density fabric the

physical property foundation with preservation of the foundation physical properties necessary as a fabric for air bag and capable of improving productive efficiency.

The fiber filling percentage in the reed is preferably 100, more preferably 90 or less, and further preferably 80 or less.

Further, it is preferable for the cover factor of the high density fabric to be defined by the following formula to be in the range of 2,000 – 2,500.

Cover factor = $A^{0.5} \times (W1) + B^{0.5} \times (W2)$

A: Coarseness of warp (dtex)

B: Coarseness of weft (dtex)

W1: Density of warp (stripes/in.)

W2: Density of weft (stripes/in.)

The fiber filling percentage is based on the definition of the filling percentage in the width direction at the time when the fibers are arrayed in the width direction in the reed wires to assume the cross section of the multifilament to be circular. When fiber stripes are densely filled in the space between the reed wires, friction between the fibers become large to make the single yarn of the multifilament more apt to be damaged. Further, when weaving speed is increased, damages of multifilament yarns are enlarged, or coiling between the single yarns becomes strong to cause degradation of physical properties of foundation. In this case, by controlling the fiber filling

percentage, damages during weaving are reduced, and production efficiency can be increased by decreasing the frequencies of machine stoppages by single yarn breakages and the like.

The fiber filling percentage is necessarily made to 110 % or less, more preferably 100 % or less, and further preferably to 90 % or less. In weaving a high density fabric, there are many cases where the weaving density is increased, and weaving is conducted at a fiber filling percentage of more than 110 % under no control. In order to reduce the fiber filling percentage, the space percentage of the reed wires is a problematic matter.

The space percentage of the reed wires is preferably in the range of 45 % or more and less than 70 %, and more preferably more than 50 % and less than 65 %. When the space percentage of the reed wires becomes less than 45 %, the fiber filling percentage in the high density fiber becomes large to cause damages to the warp fibers, and machine stoppage frequency by trouble increases in weaving due to fluff formation. In addition, foundation strength is also lowered to give undesirable results. When the space percentage of reed is made larger than 70 %, damages of weft are enlarged by input in reed to cause lowering of foundation strength and undesirable results occur. When the weaving speed is enlarged, the machine stoppage frequency is also increased, and optimization of fiber filling percentage is necessitated. The increase in the machine stoppage frequencies gives susceptibility to have effects as

the coarseness of single yarn becomes smaller.

The yarn to be used for the present invention is preferably substantially non-twist or soft twist, and especially more preferably the use of the non-twist one. This is because, in case of an attempt to obtain low air permeable fiber by using the low single yarn fineness yarn, if twist is given, spreading of single yarn is inhibited to make it difficult to obtain low air permeability.

DETAILED DESCRIPTION OF THE PREFFERD EMBODIMENT

The present invention will be further described by way of the following examples. The physical properties in the examples were measured in the following manners.

Crimp percentage: JIS (Japan Industrial Standard) L1096 6.7 B Method

Degree of intermingle: degrees of intermingle of raw yarn and unwoven yarn are measured by measuring a distance between intermingles from the displacement of the needle using a thread to which a load (formula 2) is applied and calculating the number of intermingle included in 1 meter.

Load (g) = 0.045 × fineness of multifilament (dtex) (2)

Shrinkage percentage by boiling water: JIS L1013 shrinkage percent by hot water B method, 100°C

Weaving density: JIS L1096 6.6

Tensile Strength and Elongation: JIS L1096 6.12 A method

Tearing strength: JIS L1096 6.15 A-1 method

Examples 1 to 3 and Comparative Examples 1 to 2

After weaving raw yarns 350 dtex/108f (single yarn fineness 3.3 dtex) having physical properties as shown in Table 1 as warps and wefts by plain weaving using a water jet loom, shrinking work by boiling water is made, and dry finished at 130°C to obtain a non-coated air bag fabric having a warp density of 60 yarns/in. and a weft density of 60 yarns/in. The evaluation results of this air bag fabric are shown in Table 1.

Table 1

			Example 1	Example 2	Example 3	Comparative Example 1	Comparative Example 2
Fineness		dtex	350	350	350	350	350
Number of filament		yarns	108	108	108	108	108
Single yarn		dtex/yarns	3.2	3.2	3.2	3.2	3.2
Degree of intermingle of raw yarn	warp	Times/yarn	19	19	19	31	19
	weft		19	25	25	31	19
Shrinkage percentage by boiling water	warp	%	9.2	9.2	9.2	9.2	9.2
	weft		9.2	9.2	9.2	9.2	9.2
Over feed at the time of shrinkage by boiling water	warp	%	4.5	5.5	6.5	2.5	0.0
	weft		4.0	4.5	5.0	2.0	1.0
Over feed at the time of dry setting	warp	%	0.5	0.2	0.1	1.0	2.0
	weft		0.5	0.0	0.1	0.5	1.0
Temperature of dry setting		°C	130	130	130	130	130
Density	warp	yarns/inch	60	60	60	60	60
	weft		60	60	60	60	60
Degree of intermingle of unwoven yarn	warp	times/yarn	5.9	5.3	4.8	10.2	5.4
	weft		9.5	11.2	12.1	12.5	11.0
Crimp percentage	warp	%	7.3	8.4	8.7	10.4	5.3
	weft		2.3	2.3	1.9	1.8	3.5
Air permeability (55 kPa)		1/cm2/min	2.42	2.18	2.60	3.15	3.95
Air permeability (45 kPa)		1/cm2/min	1.82	1.62	1.80	2.52	3.10
Air permeability index (50 kPa)			1.4	1.5	1.8	1.1	1.2
Cover factor			2245	2245	2245	2245	2245
Tensile Strength	warp	N/cm	580	574	578	570	576
	weft		567	553	557	564	548
Elongation	warp	%	35	34	35	36	32
	weft		29	28	29	27	28
Tearing strength	warp	N	212	208	243	224	234
	weft		220	214	224	218	228
Air permeability (50 kPa)		1/cm2/min	2.1	1.9	2.2	2.8	3.5

Examples 4 to 5 and Comparative Examples 3 to 5

After weaving raw yarns 350 dtex/72f (single yarn fineness 4.9 dtex) having physical properties as shown in Table 2 as warps and wefts by plain weaving using a water jet loom, shrinking work by boiling water is made, and dry finished at 150°C to obtain a non-coated air bag fabric having a warp density of 62 yarns/in. and a weft density of 62 yarns/in. The evaluation results of this air bag fabric are shown in Table 2.

Table 2

			Example 4	Example 5	Comparative Example 3	Comparative Example 4	Comparative Example 5
Fineness		dtex	350	350	350	350	350
Number of filament		yarns	72	72	72	72	72
Single yarn		dtex/yarns	4.9	4.9	4.9	4.9	4.9
Degree of intermingle of raw yarn	warp	times/yarn	25	25	24	33	15
	weft		25	25	24	33	8
Shrinkage percentage by boiling water	warp	%	9.4	9.4	9.4	9.4	9.4
	weft		9.4	9.4	9.4	9.4	9.4
Over feed at the time of shrinkage by boiling water	warp	%	4.5	6.0	3.5	2.0	3.5
	weft		4.5	4.5	5.5	2.5	3.5
Over feed at the time of dry setting	warp	%	0.5	0.2	1.0	1.0	0.5
	weft		0.2	0.2	0.5	1.0	0.5
Temperature of dry setting		°C	150	150	150	150	150
Density	warp	yarns/inch	62	62	62	62	62
	weft		62	62	62	62	62
Degree of intermingle of unwoven yarn	warp	times/yarn	4.3	3.9	10.8	15.2	3.0
	weft		11.5	8.9	18.5	21.1	2.2
Crimp percentage	warp	%	7.9	8.2	10.2	9.2	9.6
	weft		3.1	2.4	4.8	3.2	2.9
Air permeability (55 kPa)		1/cm2/min	2.60	2.12	2.85	4.30	3.18
Air permeability (45 kPa)		1/cm2/min	1.95	1.53	2.32	3.30	2.52
Air permeability index			1.4	1.6	1.0	1.3	1.2
Cover factor			2320	2320	2320	2320	2320
Tensile Strength	warp	N/cm	598	602	590	578	578
	weft		599	597	596	560	560
Elongation	warp	%	34	35	35	34	33
	weft		29	29	29	28	28
Tearing strength	warp	N	250	246	224	221	221
	weft		243	241	234	219	219
Air permeability (50 kPa)		1/cm2/min	2.3	1.8	2.6	3.8	2.8

According to the present invention, a fabric of low air permeability and reduced weight having a stable fabric strength and excellent air permeability characteristics under high pressures is obtained, so that it is possible to provide a high density fabric suitable for air bag.

(Example 6 - Example 9 and Comparative Example 6 - Comparative Example 8)

Using for warp non-twisted 470 dtex/72f (single yarn fineness 6.5 dtex), boiling water shrinkage percentage = 6.5 % and for weft non-twisted 470 dtex/72f, boiling water shrinkage percentage = 6.5 %, weaving was made with a reed having space percentages of 60 %, 50 %, 45 %, 40 %, and 70 %, and number of reed wires = 10.0 wires/cm, after which shrinkage processing was made with boiling water, and drying finishing was made at 140℃ to obtain a woven fabric for non-coat air bag having the warp density of 54 stripes/in. and weft density of 54 stripes/in. The results of the evaluation on the physical properties of the woven fabric for air bag are shown in Table 3.

Of the physical property measurement method, weaving density, strength and elongation were measured by the method mentioned above, and the air permeability, boiling water shrinkage percentage, and frequency of machine stoppage were measured by the following methods.

Air permeability: JIS L1096

Boiling water shrinkage percentage: JIS L1013 Boiling

water shrinkage percentage B method at 100℃.

Machine stoppage frequency: The frequency of machine stoppage in the course of the weaving operation for 10 days was converted into 24 hours. (number of times/24 hours)

[Table 3]

			Example 6	Example 7	Example 8	Example 9	Comparative Example 6	Comparative Example 7	Comparative Example 8
Warp	Filament	dtex/f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f
	Boiling water shrinkage percentage	%	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Weft	Filament	dtex/f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f	470dtex/72f
	Boiling water shrinkage percentage	%	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Reed space percentage		%	45	50	60	50	70	40	40
Number of reed wires		reeds/cm	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Number of warp inserting		yarns/reeds	2	2	2	2	2	2	2
$\sqrt{(D/\rho)}$			20.1	20.1	20.1	20.1	20.1	20.1	20.1
Fiber filling pecentage		%	100.2	90.2	75.1	90.2	64.4	112.7	112.7
Weaving speed		times/min	600	600	600	500	600	500	600
Machine stoppage frequency		number of times/24hours	12.1	8.3	4.5	3.1	4.3	16.2	39.8
Density	Warp	yarns/in.	54	54	54	54	54	54	54
	Weft	yarns/in.	54	54	54	54	54	54	54
Strength	Warp	N/cm	731	744	752	764	725	713	691
	Weft	N/cm	738	754	745	752	711	728	732
Elongation	Warp	%	34.2	34.6	32.5	33.6	32.2	33.4	33.2
	Weft	%	27.5	27.7	26.3	27.2	26.5	27.3	26.8
Air permeability		$cc/cm^2/sec$	0.10	0.09	0.10	0.11	0.11	0.10	0.10

(Example 10 – Example 13 and Comparative Example 9 – Comparative Example 11)

Using for warp non-twist 350 dtex/108f (single yarn fineness 3.2 dtex), boiling water shrinkage percentage = 9.5 % one kind, and for weft non-twist non-twist 350 dtex/108f, boiling water shrinkage percentage = 9.5 %, weaving was made in plain weave with a reed having space percentages of 45 %, 50 %, 60 %, 40 %, and 70 %, and number of reed wires = 11.5 wires/cm, after which shrinkage processing was made with warming water at 90℃, and dry set finishing was made at 140℃ to obtain a woven fabric for non-coat air bag having the warp density of 63 stripes/in. and weft density of 63 stripes/in. The results of the evaluation on the physical properties of the resulting woven fabric for air bag are shown in Table 4.

[Table 4]

			Example 10	Example 11	Example 12	Example 13	Comparative Example 9	Comparative Example 10	Comparative Example 11
Warp	Filament	dtex/f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f
	Boiling water shrinkage percentage	%	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Weft	Filament	dtex/f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f	350dtex/108f
	Boiling water shrinkage percentage	%	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Reed space percentage		%	45	50	60	50	70	40	40
Number of reed wires		reeds/cm	11.5	11.5	11.5	11.5	11.5	11.5	11.5
Number of warp inserting		yarns/reeds	2	2	2	2	2	2	2
$\sqrt{(D/\rho)}$			17.4	17.4	17.4	17.4	17.4	17.4	17.4
Fiber filling pecentage		%	99.4	89.5	74.6	89.5	63.9	111.9	111.9
Weaving speed		times/min	700	700	700	500	700	500	700
Machine stoppage frequency		number of times/24hours	16.1	6.5	3.4	2.5	3.7	15.7	43.2
Density	Warp	yarns/in.	63	63	63	63	63	63	63
	Weft	yarns/in.	63	63	63	63	63	63	63
Strength	Warp	N/cm	590	621	634	632	628	589	567
	Weft	N/cm	623	617	620	629	596	631	624
Elongation	Warp	%	35.1	35.3	35.8	35.7	36.3	35.4	33.8
	Weft	%	27.3	27.8	27.7	27.5	26.9	27.4	27.2
Air permeability		$cc/cm^2/sec$	0.06	0.07	0.06	0.06	0.07	0.07	0.06

As will be clear from Tables 3 and 4, it can be seen that the weaving method according to the present invention is suitable for producing a foundation for low air permeable air bag without causing degradation to the strength physical properties when the weaving speed is increased.

In consequence of the contrivances as above, it has become possible to provide a method for producing low air permeable high density woven fabric in good efficiency while preserving the mechanical strength necessary as the woven fabric for air bag.